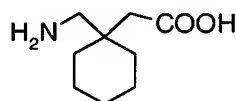


Method of Treatment for Sexual Dysfunction

This invention relates to a new use of alpha-2-delta ligands and their pharmaceutically acceptable derivatives. In particular it relates to a new use of
 5 gabapentin, pregabalin, (1 α ,3 α ,5 α)(3-amino-methyl-bicyclo[3.2.0]hept-3-yl)-acetic acid and [(1R,5R,6S)-6-(Aminomethyl)bicyclo[3.2.0]hept-6-yl]acetic acid.

Premature ejaculation may be defined as persistent or recurrent ejaculation before, upon or shortly after penile penetration of a sexual partner. It may also be defined
 10 as ejaculation occurring before the individual wishes [see 'The Merck Manual', 16th edition, p 1576, published by Merck Research Laboratories, 1992].

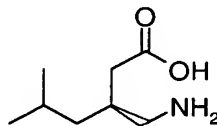
Alpha-2-delta ligands have been described for a number of indications. The best known alpha-2-delta ligand, gabapentin (I), known as Neurontin®, 1-(aminomethyl)-
 15 cyclohexylacetic acid, was first described in the patent literature in the patent family comprising US4024175.



(I)

The compound is approved for the treatment of epilepsy and neuropathic pain.

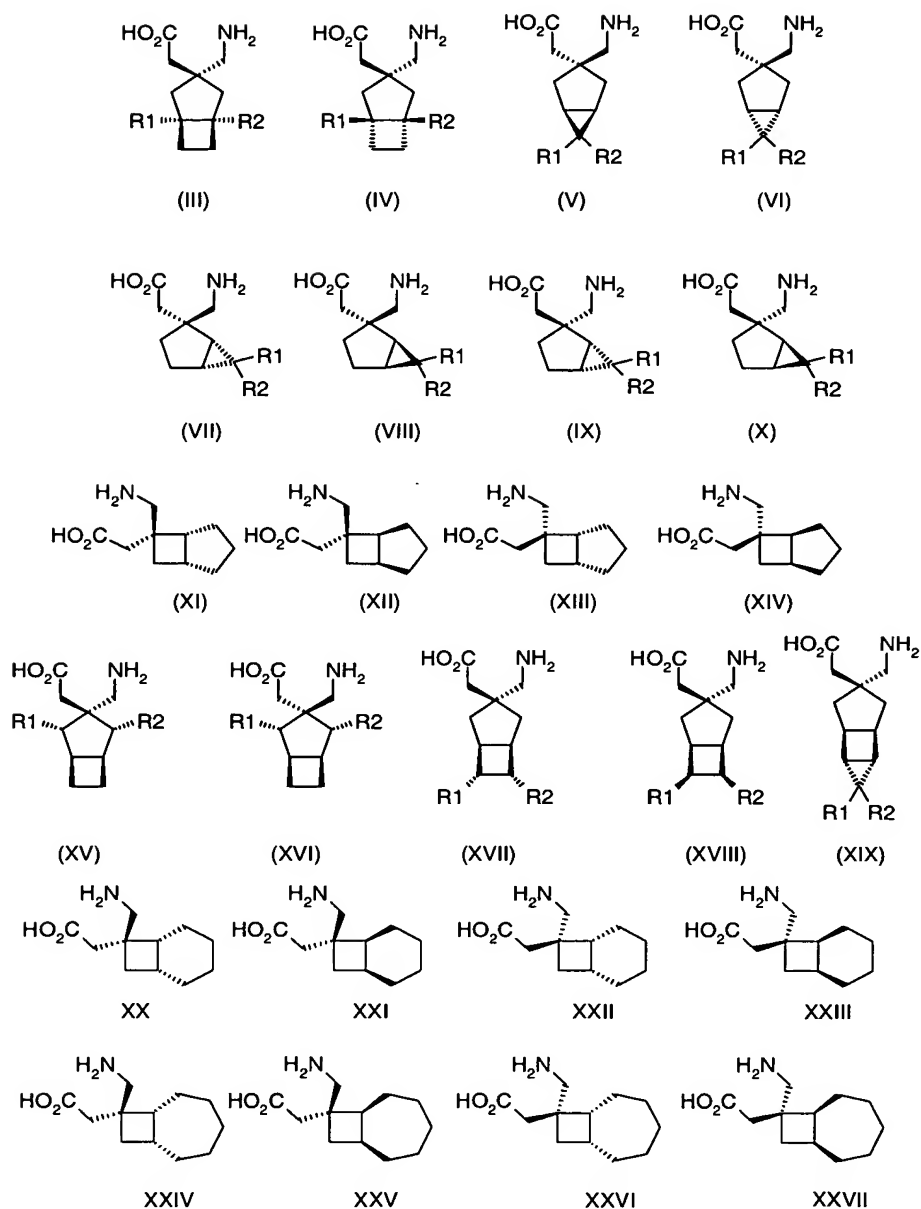
20 A second alpha-2-delta ligand, pregabalin (II), (S)-(+)-4-amino-3-(2-methylpropyl)butanoic acid, is described in European patent application publication number EP641330 as an anti-convulsant treatment useful in the treatment of epilepsy and in EP0934061 for the treatment of pain.



(II)

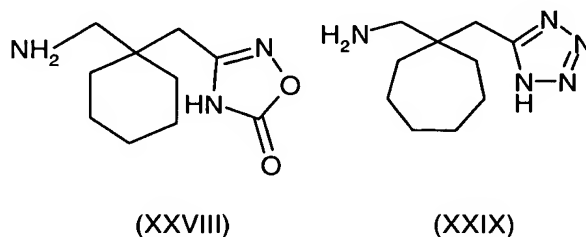
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More recently, Patent Application WO02/085839 describes alpha-2-delta ligands of the following formulae:

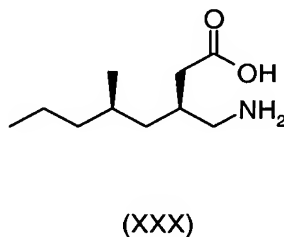


wherein R^1 and R^2 are each independently selected from H, straight or branched alkyl of 1-6 carbon atoms, cycloalkyl of from 3-6 carbon atoms, phenyl and benzyl, subject to the proviso that, except in the case of a tricyclooctane compound of formula (XVIII), R^1 and R^2 are not simultaneously hydrogen; for use in the treatment of a number of indications, including pain.

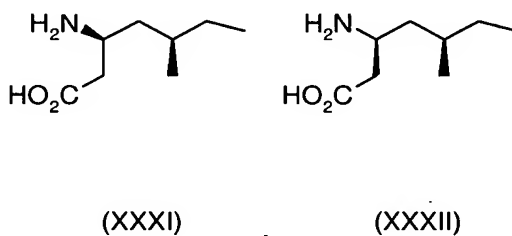
Further examples of alpha-2-delta ligands are those compounds generally or specifically disclosed in US4024175, US5563175, WO9733858, WO9733859, WO9931057, WO9931074, WO9729101, WO9931075. Particularly of interest are



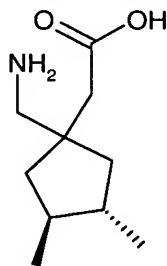
5 disclosed in WO9931075; and



disclosed in WO0076958; and



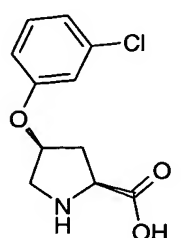
disclosed in US Application Serial No. 60/368413; and



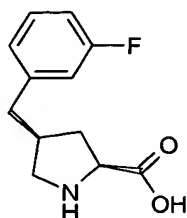
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WO 00/61135 describes the use of analogs of glutamic acid and gamma-aminobutyric acid as being useful in treating incontinence.

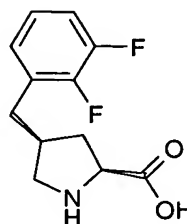
Further examples of alpha-2-delta ligands are the compounds depicted below:



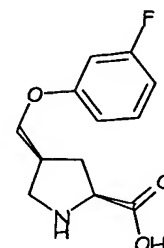
XXXIV



XXXV

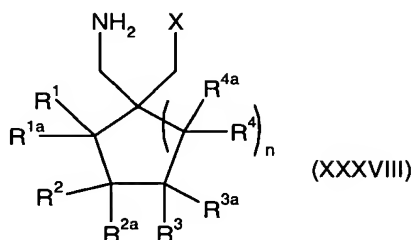


XXXVI



XXXVII

- 5 Additional cyclic alpha-2-delta ligands of the present invention are illustrated by the following formula (XXXVIII):



(XXXVIII)

wherein X is a carboxylic acid or carboxylic acid bioisostere;

n is 0, 1 or 2; and

- 10 R¹, R^{1a}, R², R^{2a}, R³, R^{3a}, R⁴ and R^{4a} are independently selected from H and C₁-C₆ alkyl, or

R¹ and R² or R² and R³ are taken together to form a C₃-C₇ cycloalkyl ring, which is optionally substituted with one or two substituents selected from C₁-C₆ alkyl, or a pharmaceutically acceptable salt thereof.

15

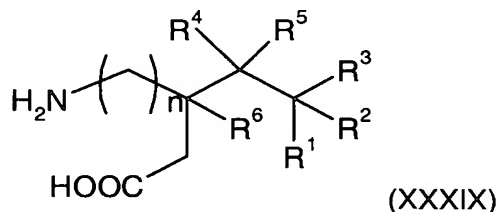
In formula (XXXVIII), suitably, R¹, R^{1a}, R^{2a}, R^{3a}, R⁴ and R^{4a} are H and R² and R³ are independently selected from H and methyl, or R^{1a}, R^{2a}, R^{3a} and R^{4a} are H and R¹ and R² or R² and R³ are taken together to form a C₃-C₇ cycloalkyl ring, which is optionally substituted with one or two methyl substituents. A suitable carboxylic

- 20 acid bioisostere is selected from tetrazolyl and oxadiazolonyl. X is preferably a carboxylic acid.

In formula (XXXVIII), preferably, R¹, R^{1a}, R^{2a}, R^{3a}, R⁴ and R^{4a} are H and R² and R³ are independently selected from H and methyl, or R^{1a}, R^{2a}, R^{3a} and R^{4a} are H and

R^1 and R^2 or R^2 and R^3 are taken together to form a C_4 - C_5 cycloalkyl ring, or, when n is 0, R^1 , R^{1a} , R^{2a} , R^{3a} , R^4 and R^{4a} are H and R^2 and R^3 form a cyclopentyl ring, or, when n is 1, R^1 , R^{1a} , R^{2a} , R^{3a} , R^4 and R^{4a} are H and R^2 and R^3 are both methyl or R^1 , R^{1a} , R^{2a} , R^{3a} , R^4 and R^{4a} are H and R^2 and R^3 form a cyclobutyl ring, or, when n is 2, R^1 , R^{1a} , R^2 , R^{2a} , R^3 , R^{3a} , R^4 and R^{4a} are H, or, n is 0, R^1 , R^{1a} , R^{2a} , R^{3a} , R^4 and R^{4a} are H and R^2 and R^3 form a cyclopentyl ring.

Further acyclic alpha-2-delta ligands of the present invention are illustrated by the following formula (XXXIX):



wherein:

n is 0 or 1, R^1 is hydrogen or (C_1-C_6) alkyl; R^2 is hydrogen or (C_1-C_6) alkyl; R^3 is hydrogen or (C_1-C_6) alkyl; R^4 is hydrogen or (C_1-C_6) alkyl; R^5 is hydrogen or (C_1-C_6) alkyl and R^6 is hydrogen or (C_1-C_6) alkyl, or a pharmaceutically acceptable salt thereof.

15

According to formula (XXXIX), suitably R^1 is C_1 - C_6 alkyl, R^2 is methyl, $R^3 - R^6$ are hydrogen and n is 0 or 1. More suitably R^1 is methyl, ethyl, n-propyl or n-butyl, R^2 is methyl, $R^3 - R^6$ are hydrogen and n is 0 or 1. When R^2 is methyl, $R^3 - R^6$ are hydrogen and n is 0, R^1 is suitably ethyl, n-propyl or n-butyl. When R^2 is methyl, $R^3 - R^6$ are hydrogen and n is 1, R^1 is suitably methyl or n-propyl. Compounds of formula (II) are suitably in the 3S,5R configuration.

Examples of alpha-2-delta ligands for use with the present invention include those compounds generally or specifically disclosed in US4024175, particularly gabapentin, EP641330, particularly pregabalin, US5563175, WO9733858, WO9733859, WO9931057, WO9931074, WO9729101, WO02085839, particularly [(1R,5R,6S)-6-(Aminomethyl)bicyclo[3.2.0]hept-6-yl]acetic acid, WO9931075, particularly 3-(1-Aminomethyl-cyclohexylmethyl)-4H-[1,2,4]oxadiazol-5-one and C-[1-(1H-Tetrazol-5-ylmethyl)-cycloheptyl]-methylamine, WO9921824, particularly (3S,4S)-(1-Aminomethyl-3,4-dimethyl-cyclopentyl)-acetic acid, WO0190052, WO0128978, particularly (1 α ,3 α ,5 α)-(3-amino-methyl-bicyclo[3.2.0]hept-3-yl)-acetic acid, EP0641330,

30

WO9817627, WO0076958, particularly (3S,5R)-3-aminomethyl-5-methyl-octanoic acid, PCT/IB03/00976, particularly (3S,5R)-3-amino-5-methyl-heptanoic acid, (3S,5R)-3-amino-5-methyl-nonanoic acid and (3S,5R)-3-Amino-5-methyl-octanoic acid, EP1178034, EP1201240, WO9931074, WO03000642, WO0222568, WO0230871,
5 WO0230881, WO02100392, WO02100347, WO0242414, WO0232736 and WO0228881 or pharmaceutically acceptable salts thereof, all of which are incorporated herein by reference.

Surprisingly, it has been found that alpha-2-delta ligands, such as those described above,
10 are useful in the treatment of premature ejaculation.

Thus, in accordance with the present invention there is provided the use of an alpha-2-delta ligand for the treatment of premature ejaculation.

15 In a preferred embodiment the alpha-2-delta ligand is administered on an as needed basis, also known as *pro re nata* dosing, referred to herein as prn administration.

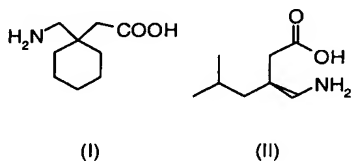
Suitable alpha-2-delta ligands are those with a binding affinity of less than about 1000nM
Preferred alpha-2-delta ligands are those with a binding affinity of less than about 300nM
20 More preferred alpha-2-delta ligands are those with a binding affinity of less than about 100nM

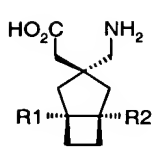
Most preferred are those alpha-2-delta ligands are those with a binding affinity of less than about 50nM.

25 The biological activity of the alpha-2-delta ligands of the invention may be measured in a radioligand binding assay using [³H]gabapentin and the $\alpha_2\delta$ subunit derived from porcine brain tissue (Gee N.S., Brown J.P., Dissanayake V.U.K., Offord J., Thurlow R., Woodruff G.N., *J. Biol. Chem.*, 1996;271:5879-5776). Results may be expressed in terms of μ M or nM $\alpha_2\delta$ binding affinity.

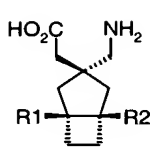
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Preferably the alpha-2-delta-1-ligand is selected from:

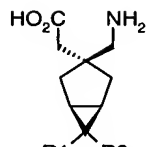




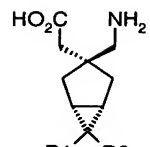
(III)



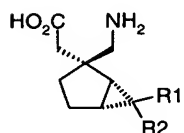
(IV)



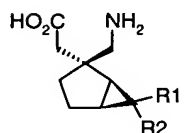
(V)



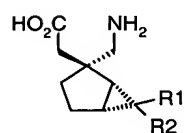
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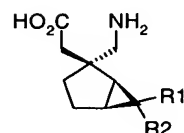
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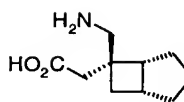
(VIII)



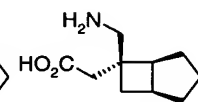
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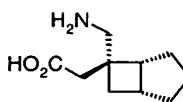
(X)



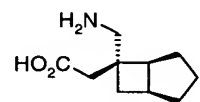
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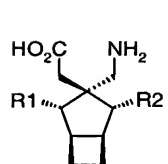
(XII)



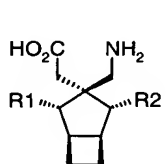
(XIII)



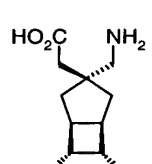
(XIV)



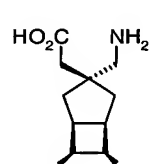
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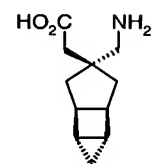
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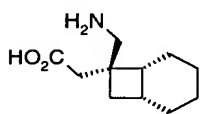
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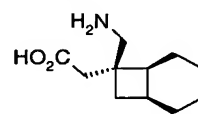
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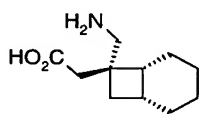
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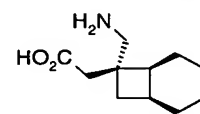
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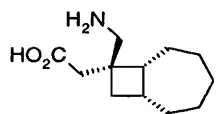
XXI



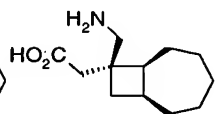
XXII



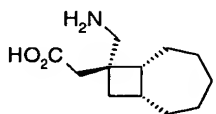
XXIII



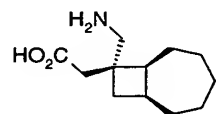
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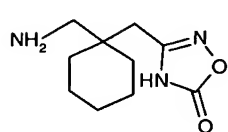
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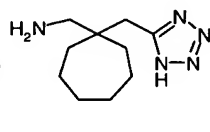
XXVI



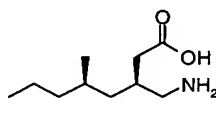
XXVII



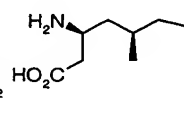
(XXVIII)



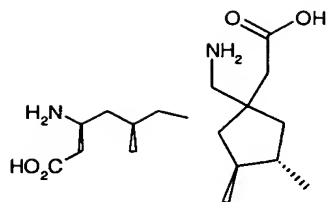
(XXIX)



(XXX)

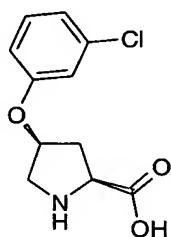


(XXXI)

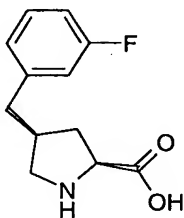


(XXXII) (XXXIII) ; or a pharmaceutically acceptable derivative

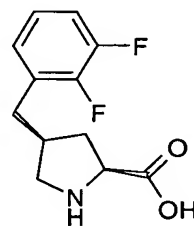
thereof, wherein R^1 and R^2 are each independently selected from H, straight or branched alkyl of 1-6 carbon atoms, cycloalkyl of from 3-6 carbon atoms, phenyl and benzyl, subject to the proviso that, except in the case of a tricyclooctane compound of formula (XVIII), R^1 and R^2 are not simultaneously hydrogen;



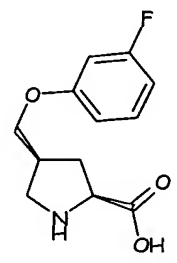
XXXIV



XXXV



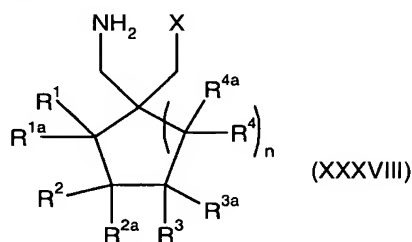
XXXVI



XXXVII

10

compounds of formula (XXXVIII):



(XXXVIII)

wherein X is a carboxylic acid or carboxylic acid bioisostere;

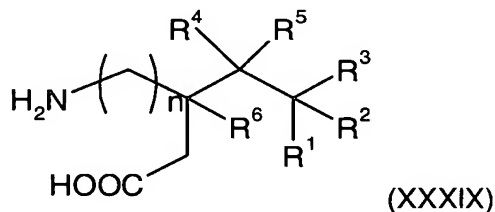
n is 0, 1 or 2; and

15 R^1 , R^{1a} , R^2 , R^{2a} , R^3 , R^{3a} , R^4 and R^{4a} are independently selected from H and C_1 - C_6 alkyl, or R^1 and R^2 or R^2 and R^3 are taken together to form a C_3 - C_7 cycloalkyl ring, which is optionally substituted with one or two substituents selected from C_1 - C_6 alkyl, or a pharmaceutically acceptable salt thereof.

In formula (XXXVIII), suitably, R^1 , R^{1a} , R^{2a} , R^{3a} , R^4 and R^{4a} are H and R^2 and R^3 are independently selected from H and methyl, or R^{1a} , R^{2a} , R^{3a} and R^{4a} are H and R^1 and R^2 or R^2 and R^3 are taken together to form a C_3 - C_7 cycloalkyl ring, which is optionally substituted with one or two methyl substituents. A suitable carboxylic acid bioisostere is selected from tetrazolyl and oxadiazolonyl. X is preferably a carboxylic acid.

In formula (XXXVIII), preferably, R^1 , R^{1a} , R^{2a} , R^{3a} , R^4 and R^{4a} are H and R^2 and R^3 are independently selected from H and methyl, or R^{1a} , R^{2a} , R^{3a} and R^{4a} are H and R^1 and R^2 or R^2 and R^3 are taken together to form a C_4 - C_5 cycloalkyl ring, or, when n is 0, R^1 , R^{1a} , R^{2a} , R^{3a} , R^4 and R^{4a} are H and R^2 and R^3 form a cyclopentyl ring, or, when n is 1, R^1 , R^{1a} , R^{2a} , R^{3a} , R^4 and R^{4a} are H and R^2 and R^3 are both methyl or R^1 , R^{1a} , R^{2a} , R^{3a} , R^4 and R^{4a} are H and R^2 and R^3 form a cyclobutyl ring, or, when n is 2, R^1 , R^{1a} , R^2 , R^{2a} , R^3 , R^{3a} , R^4 and R^{4a} are H, or, n is 0, R^1 , R^{1a} , R^{2a} , R^{3a} , R^4 and R^{4a} are H and R^2 and R^3 form a cyclopentyl ring;

Compounds of formula (XXXIX):



wherein:

n is 0 or 1, R^1 is hydrogen or (C_1-C_6) alkyl; R^2 is hydrogen or (C_1-C_6) alkyl; R^3 is hydrogen or (C_1-C_6) alkyl; R^4 is hydrogen or (C_1-C_6) alkyl; R^5 is hydrogen or (C_1-C_6) alkyl and R^6 is hydrogen or (C_1-C_6) alkyl, or a pharmaceutically acceptable salt thereof.

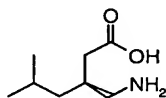
According to formula (XXXIX), suitably R^1 is C_1-C_6 alkyl, R^2 is methyl, $R^3 - R^6$ are hydrogen and n is 0 or 1. More suitably R^1 is methyl, ethyl, n-propyl or n-butyl, R^2 is methyl, $R^3 - R^6$ are hydrogen and n is 0 or 1. When R^2 is methyl, $R^3 - R^6$ are hydrogen and n is 0, R^1 is suitably ethyl, n-propyl or n-butyl. When R^2 is methyl, $R^3 - R^6$ are hydrogen and n is 1, R^1 is suitably methyl or n-propyl. Compounds of formula (XXXIX) are suitably in the 3S,5R configuration.

Examples of alpha-2-delta ligands for use with the present invention include those compounds generally or specifically disclosed in US4024175, particularly gabapentin,

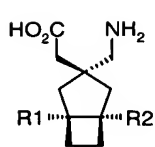
EP641330, particularly pregabalin, US5563175, WO9733858, WO9733859, WO9931057, WO9931074, WO9729101, WO02085839, particularly [(1R,5R,6S)-6-(Aminomethyl)bicyclo[3.2.0]hept-6-yl]acetic acid, WO9931075, particularly 3-(1-Aminomethyl-cyclohexylmethyl)- 4H-[1,2,4]oxadiazol-5-one and C-[1-(1H-Tetrazol-5-ylmethyl)-cycloheptyl]-methylamine, WO9921824, particularly (3S,4S)-(1-Aminomethyl-3,4-dimethyl-cyclopentyl)-acetic acid, WO0190052, WO0128978, particularly (1 α ,3 α ,5 α)-(3-amino-methyl-bicyclo[3.2.0]hept-3-yl)-acetic acid, EP0641330, WO9817627, WO0076958, particularly (3S,5R)-3-aminomethyl-5-methyl-octanoic acid, PCT/IB03/00976, particularly (3S,5R)-3-amino-5-methyl-heptanoic acid, (3S,5R)-3-amino-5-methyl-nonanoic acid and (3S,5R)-3-Amino-5-methyl-octanoic acid, EP1178034, EP1201240, WO9931074, WO03000642, WO0222568, WO0230871, WO0230881, WO02100392, WO02100347, WO0242414, WO0232736 and WO0228881 or pharmaceutically acceptable salts thereof, all of which are incorporated herein by reference.

15

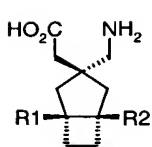
More preferably the alpha-2-delta ligand is



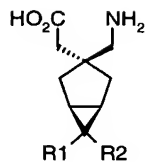
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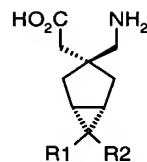
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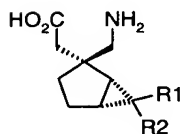
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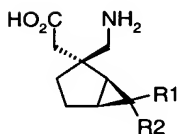
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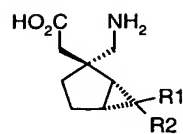
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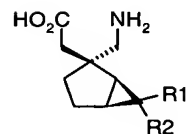
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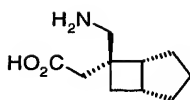
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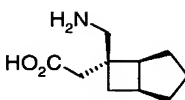
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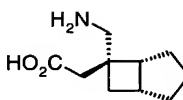
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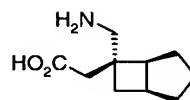
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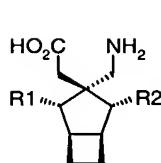
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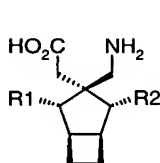
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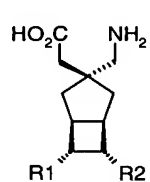
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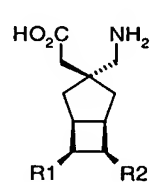
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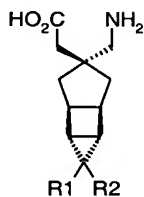
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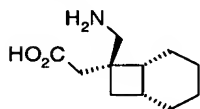
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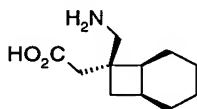
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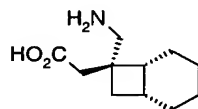
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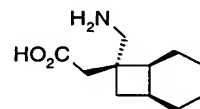
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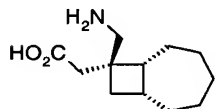
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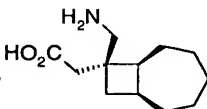
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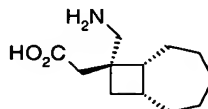
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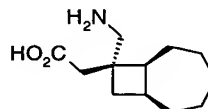
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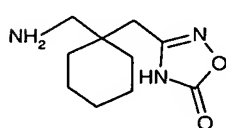
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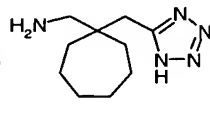
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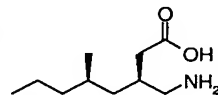
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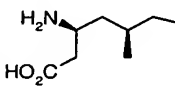
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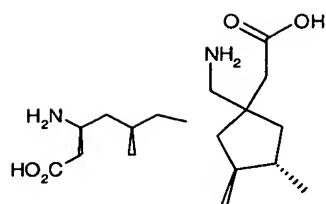
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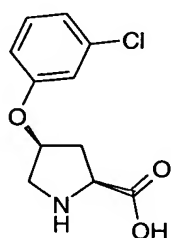


(XXXI)

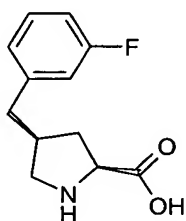


(XXXII) (XXXIII) ; or a pharmaceutically acceptable derivative

thereof, wherein R^1 and R^2 are each independently selected from H, straight or branched alkyl of 1-6 carbon atoms, cycloalkyl of from 3-6 carbon atoms, phenyl and benzyl, subject to the proviso that, except in the case of a tricyclooctane compound of formula (XVIII), R^1 and R^2 are not simultaneously hydrogen; and



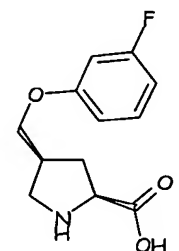
XXXIV



XXXV

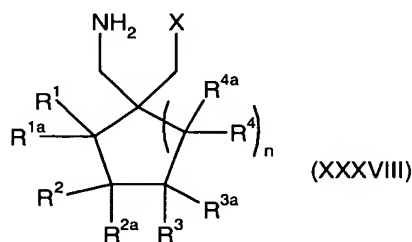


XXXVI



XXXVII

10 compounds of formula (XXXVIII):

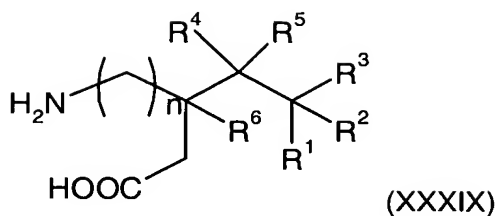


wherein X is a carboxylic acid or carboxylic acid bioisostere;

n is 0, 1 or 2; and

R^1 , R^{1a} , R^{2a} , R^{3a} , R^4 and R^{4a} are H and R^2 and R^3 are independently selected from H and methyl, or R^{1a} , R^{2a} , R^{3a} and R^{4a} are H and R^1 and R^2 or R^2 and R^3 are taken together to form a C_4 - C_5 cycloalkyl ring, or pharmaceutically acceptable salt thereof;

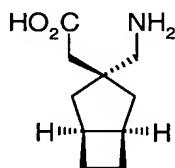
Compounds of formula (XXXIX):



wherein:

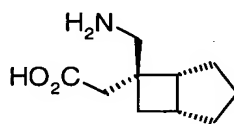
R¹ is methyl, ethyl, n-propyl or n-butyl, R² is methyl, R³ – R⁶ are hydrogen and n is 0 or 1, or a pharmaceutically acceptable salt thereof. Compounds of formula (XXXIX) are in the 3S,5R configuration.

Yet more preferably the alpha-2-delta ligand is pregabalin (II), (1 α ,3 α ,5 α)(3-amino-methyl-bicyclo[3.2.0]hept-3-yl)-acetic acid (III')



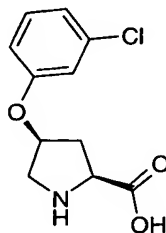
(III')

, [(1R,5R,6S)-6-(Aminomethyl)bicyclo[3.2.0]hept-6-yl]acetic acid;



(XI)

and (2S, 4S)-4-(3-Chloro-phenoxy)-pyrrolidine-2-carboxylic acid



(XXXIV)

Yet even more preferably the alpha-2-delta ligand is [(1R,5R,6S)-6-(Aminomethyl)bicyclo[3.2.0]hept-6-yl]acetic acid or (2S, 4S)-4-(3-Chloro-phenoxy)-pyrrolidine-2-carboxylic acid.

5 Most preferably the alpha-2-delta ligand is [(1R,5R,6S)-6-(Aminomethyl)bicyclo[3.2.0]hept-6-yl]acetic acid.

The alpha-2-delta ligand, or pharmaceutically acceptable derivative thereof, can be administered alone or in any convenient pharmaceutical presentation. Oral administration
10 is preferred. In the present indication, a suitable dosage of the alpha-2-delta ligand, or of the active moiety in a pharmaceutically acceptable derivative thereof, is from about 5 to 50 mg/kg of body weight, and preferably about 0.1 to 200 mg/kg. In a more preferred embodiment the dosage is 5 to 15mg/kg of body weight, most preferably 10mg/kg of body weight.

15

The invention further provides a method of treating premature ejaculation comprising administering an alpha-2-delta ligand, or pharmaceutically acceptable derivative thereof, to a patient in need of such treatment.

20 Alpha-2-delta ligands, particularly the compounds described above, may be used in combination with other compounds. Thus, a further aspect of the present invention is the use of an alpha-2-delta ligand for the manufacture of a medicament in combination with an additional therapeutic agent for the treatment of premature ejaculation. Still further there is provided a product containing an alpha-2-delta ligand and an additional
25 therapeutic agent as a combined preparation for simultaneous, separate or sequential use in the treatment of premature ejaculation.

Suitable additional therapeutic agents include:

- 30
- Apomorphine - teachings on the use of apomorphine as a pharmaceutical may be found in US-A-5945117;
 - Dopamine receptor antagonists, particularly dopamine D2, D3 and D4 antagonists such as Premipruxal, Pharmacia Upjohn compound number PNU95666 or levosulphiride;

- A serotonin receptor antagonist or modulator, more particularly antagonists or modulators for 5HT_{1A}, including NAD-299 (robalzotan) and WAY-100635, and/or more particularly antagonists or modulators for 5HT₃ receptors, including batanopirde, granisetron, ondansetron, tropistron and MDL-73147EF;
- 5 ◦ A serotonin receptor agonist or modulator, more particularly agonists or modulators for 5HT_{2C}, 5HT_{1B} and/or 5HT_{1D} receptors, including anpirtoline, sumatriptan, eletriptan, frovatriptan, and other triptans well known as anti-migraine medication;
- 10 ◦ An α -adrenergic receptor antagonist (also known as α -adrenergic blockers, α -blockers or α -receptor blockers); suitable α ₁-adrenergic receptor antagonists include: phentolamine, prazosin, phentolamine mesylate, trazodone, alfuzosin, indoramin, naftopidil, tamsulosin, phenoxybenzamine, rauwolfia alkaloids, Recordati 15/2739, SNAP 1069, SNAP 5089, RS17053, SL 89.0591, doxazosin, terazosin and abanoquil; suitable α ₂-adrenergic receptor antagonists include
15 dibenamine, tolazoline, trimazosin, efaroxan, yohimbine, idazoxan clonidine and dibenamine; suitable non-selective α -adrenergic receptor antagonists include
20 dapiprazole; further α -adrenergic receptor antagonists are described in WO99/30697, US4,188,390, US4,026,894, US3,511,836, US4,315,007, US3,527,761, US3,997,666, US2,503,059, US 4,703,063, US 3,381,009, US 4,252,721 and US 2,599,000 each of which is incorporated herein by reference;
- oxytocin receptor antagonists, e.g. L-368 899 (The synthesis of L-368,899 is taught in Williams *et al* (1994) J. Med. Chem. 37, 565-571).
- Vasopressin receptor antagonists

25

The contents of the published patent applications and in particular the general formulae of the therapeutically active compounds of the claims and exemplified compounds therein are incorporated herein in their entirety by reference thereto.

30

The use of the compounds and combinations described herein may have the advantage that higher potency, longer duration of action, fewer side effects, improved selectivity, or other more useful properties are achieved compared to the uses of the prior art.

The efficacy of treating premature ejaculation with alpha-2-delta ligands may be demonstrated by use of the anaesthetised rat model of premature ejaculation (Yonezawa et al (2000) Life Sciences 67, 3031-3039)

- 5 Alpha-2-delta ligands have been shown to be efficacious in treating premature ejaculation using such a model.

The compounds of the present invention can be administered alone but will generally be administered in admixture with a suitable pharmaceutical excipient, diluent or carrier
10 selected with regard to the intended route of administration and standard pharmaceutical practice.

For example, the compounds of the present invention can be administered orally, buccally or sublingually in the form of tablets, capsules, ovules, elixirs, solutions or suspensions,
15 which may contain flavouring or colouring agents, for immediate-, delayed-, modified-, sustained-, pulsed- or controlled-release applications.

Such tablets may contain excipients such as microcrystalline cellulose, lactose, sodium citrate, calcium carbonate, dibasic calcium phosphate and glycine, disintegrants such as
20 starch (preferably corn, potato or tapioca starch), sodium starch glycollate, croscarmellose sodium and certain complex silicates, and granulation binders such as polyvinylpyrrolidone, hydroxypropylmethylcellulose (HPMC), hydroxypropylcellulose (HPC), sucrose, gelatin and acacia. Additionally, lubricating agents such as magnesium stearate, stearic acid, glyceryl behenate and talc may be included.

25 Solid compositions of a similar type may also be employed as fillers in gelatin capsules. Preferred excipients in this regard include lactose, starch, a cellulose, milk sugar or high molecular weight polyethylene glycols. For aqueous suspensions and/or elixirs, the compounds of the present invention may be combined with various sweetening or
30 flavouring agents, colouring matter or dyes, with emulsifying and/or suspending agents and with diluents such as water, ethanol, propylene glycol and glycerin, and combinations thereof.

The compounds of the present invention can also be administered parenterally, for
35 example, intravenously, intra-arterially, intraperitoneally, intrathecally, intraventricularly,

intraurethrally, intrasternally, intracranially, intramuscularly or subcutaneously, or they may be administered by infusion techniques. For such parenteral administration they are best used in the form of a sterile aqueous solution which may contain other substances, for example, enough salts or glucose to make the solution isotonic with blood. The aqueous solutions should be suitably buffered (preferably to a pH of from 3 to 9), if necessary. The preparation of suitable parenteral formulations under sterile conditions is readily accomplished by standard pharmaceutical techniques well-known to those skilled in the art.

10 The compounds of the present invention can also be administered intranasally or by inhalation and are conveniently delivered in the form of a dry powder inhaler or an aerosol spray presentation from a pressurised container, pump, spray, atomiser or nebuliser, with or without the use of a suitable propellant, e.g. dichlorodifluoromethane, trichlorofluoromethane, dichlorotetrafluoroethane, a hydrofluoroalkane such as 1,1,1,2-tetrafluoroethane (HFA 134A [trade mark]) or 1,1,1,2,3,3,3-heptafluoropropane (HFA 227EA [trade mark]), carbon dioxide or other suitable gas. In the case of a pressurised aerosol, the dosage unit may be determined by providing a valve to deliver a metered amount. The pressurised container, pump, spray, atomiser or nebuliser may contain a solution or suspension of the active compound, e.g. using a mixture of ethanol and the propellant as the solvent, which may additionally contain a lubricant, e.g. sorbitan trioleate. Capsules and cartridges (made, for example, from gelatin) for use in an inhaler or insufflator may be formulated to contain a powder mix of the therapeutic agents and a suitable powder base such as lactose or starch.

25 Alternatively, the compounds of the present invention can be administered in the form of a suppository or pessary, or they may be applied topically in the form of a gel, hydrogel, lotion, solution, cream, ointment or dusting powder. The compounds of the present invention may also be dermally or transdermally administered, for example, by the use of a skin patch. They may also be administered by the pulmonary or rectal routes.

30 For application topically to the skin, the compounds of the present invention can be formulated as a suitable ointment containing the active compound suspended or dissolved in, for example, a mixture with one or more of the following: mineral oil, liquid petrolatum, white petrolatum, propylene glycol, polyoxyethylene polyoxypropylene compound,

emulsifying wax and water. Alternatively, they can be formulated as a suitable lotion or cream, suspended

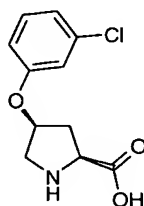
or dissolved in, for example, a mixture of one or more of the following: mineral oil, sorbitan monostearate, a polyethylene glycol, liquid paraffin, polysorbate 60, cetyl esters wax,
5 cetearyl alcohol, 2-octyldodecanol, benzyl alcohol and water.

The compounds of the present invention may also be used in combination with a cyclodextrin. Cyclodextrins are known to form inclusion and non-inclusion complexes with drug molecules. Formation of a drug-cyclodextrin complex may modify the solubility,
10 dissolution rate, bioavailability and/or stability property of a drug molecule. Drug-cyclodextrin complexes are generally useful for most dosage forms and administration routes. As an alternative to direct complexation with the drug the cyclodextrin may be used as an auxiliary additive, e.g. as a carrier, diluent or solubiliser. Alpha-, beta- and gamma-cyclodextrins are most commonly used and suitable examples are described in
15 WO-A-91/11172, WO-A-94/02518 and WO-A-98/55148.

Suitable alpha-2-delta ligand compounds of the present invention may be prepared as described herein below or in the aforementioned patent literature references.

20 Example 1

(2S, 4S)-4-(3-Chloro-phenoxy)-pyrrolidine-2-carboxylic acid



A solution of preparation 2 (29.25mol) was dissolved in THF (20L) & filtered. To this solution was added 4M HCl in dioxane (30L) & stirred overnight. Tert-Butyl methyl
25 ether (70L) was added to the resultant suspension & the product was collected by filtration (7.06kg, 86.7%).

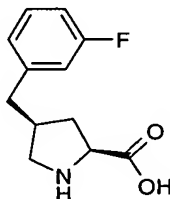
¹H NMR (400 MHz, CD₃OD): δ = 2.65 (m, 2H), 3.60 (dd, 1H), 3.70 (d, 1H), 4.60 (dd, 1H), 5.02 (m, 1H), 6.88 (m, 1H), 6.97 (s, 1H), 7.03 (d, 1H), 7.29 (dd, 1H).

LRMS (Electrospray [MH⁺]) 242, [M-1] 240.

30 Microanalysis: Found, C, 46.97; H, 4.70; N, 4.90. C₁₁H₁₂ClNO₃·HCl·0.1H₂O requires C, 47.20; H, 4.75; N, 5.00.

Example 2

(2*S*,4*S*)-4-(3-Fluoro-benzyl)-pyrrolidine-2-carboxylic acid mono hydrochloride salt

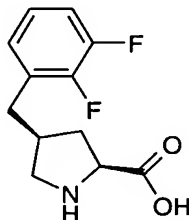


5 4-(3-Fluoro-benzyl)-pyrrolidine-1,2-dicarboxylic acid 1-tert-butyl ester 2-(2-isopropyl-5-methyl-cyclohexyl) ester (Preparation 3, 0.91 g, 1.96 mmol) was dissolved in toluene (2 ml). 6N hydrochloric acid (50ml) was added and stirred at reflux for 18 h. The reaction mixture was cooled to room temperature and extracted with ethyl acetate (3 x 20 ml). The aqueous layer was concentrated by evaporated under reduced pressure to give
10 the title compound (417mg, 81 %) as a white solid. ¹H-NMR showed a 7:1 ratio of *cis:trans* diastereoisomers so the product was recrystallised from isopropyl alcohol to give the title compound (170mg, 65%) in a ratio of 14:1 *cis:trans* as determined by NMR.
¹H-NMR (400MHz, CD₃OD): (mixture of diastereoisomers 2*S*,4*S*:2*S*,4*R* (14:1)): δ = 1.85 (q, 1H), 2.51 (quin, 1H), 2.69-2.85 (m, 3H), 3.07 (t, 1H), 3.41 (dd, 1H), 4.38 and 4.48 (t,
15 1H), 6.90-7.04 (m, 3H), 7.32 (q, 1H).
LRMS (APCI): m/z [MH]⁺ 224.
[α]_D²⁵ -1.27° (c=9.00 in methanol).
Microanalysis: Found C, 55.56; H, 5.81; N, 5.34%. C₁₂H₁₄FNO₂.HCl requires C, 55.50; H, 5.82; N, 5.39%.

20

Example 3

(2*S*,4*S*)-4-(2,3-Difluoro-benzyl)-pyrrolidine-2-carboxylic acid mono-hydrochloride salt



25 The title compound was made from by the method of Example 2, starting from the title compound of Preparation 4, and purified by re-crystallisation with acetone/ether to

give the title compound as a mixture of diastereoisomers (2*S*,4*S*:2*S*,4*R* (12:1)) determined by ¹H-NMR (500 mg, 60 %) as a white solid.

¹H-NMR (400 MHz, CD₃OD) (mixture of diastereoisomers *cis* :*trans* (12:1)): δ= 0.80-1.90 (m, 0.92H), 2.12-2.20 (m, 0.08H), 2.28-2.36 (m, 0.08H), 2.49-2.58 (q, 0.92H), 2.66-2.81 (m, 1H), 2.83-2.95 (m, 2H), 3.02-3.13 (t, 1H), 3.46 (dd, 1H), 4.40 (dd, 0.92H), 4.48-4.54 (m, 0.08H), 7.03-7.20 (m, 3H).

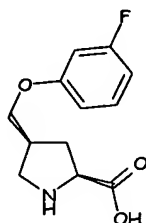
LRMS (Electrospray): m/z [M + H]⁺ 242.

Microanalysis: Found C, 51.42; H, 5.08; N, 5.01%. C₁₂H₁₃NO₂F₂.HCl requires C, 51.90; H, 5.08; N, 5.04%.

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Example 4

(2*S*,4*S*)-4-(3-fluoro-phenoxy)methyl-pyrrolidine-2-carboxylic acid



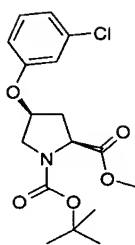
4-(3-fluoro-phenoxy)methyl-pyrroline-1,2-dicarboxylic acid di-*tert*-butyl ester (Preparation 5, 475mg, 1.2mmol) was dissolved in a solution of anhydrous hydrogen chloride in dioxane (4M, 15ml) and stirred at 50°C under a nitrogen atmosphere for 1 hour. The solvent was removed under reduced pressure and the resulting semi-solid triturated with ethyl acetate to give a white solid which was recrystallised from ethyl acetate/isopropyl alcohol to give the title compound as a mixture of diastereomers (~5:1 2*S*,4*S*:2*S*,4*R*) as a white solid hydrochloride salt (90mg, 35%)

¹H-NMR (400MHz, CD₃OD): δ = 2.04-2.09 (m, 0.8H); 2.33-2.47 (m, 0.4H); 2.65-2.75 (m, 0.8H); 2.88-3.00 (m, 1H); 3.33-3.40 (m, 1H); 3.52-3.60 (m, 0.8H); 3.60-3.68 (0.2H); 3.96-4.04 (m, 1H); 4.04-4.12 (m, 1H); 4.42-4.51 (m, 0.8H); 4.40-4.56 (m, 0.2H); 6.65-6.80 (m, 3H), 7.21-7.30 (m, 1H)

LRMS (electrospray): [M+1] 240; [M+23] 262; [M-1] 238.

Preparation 1

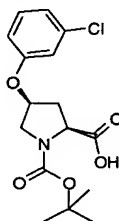
(2*S*, 4*S*)-4-(3-Chloro-phenoxy)-pyrrolidine-1,2-dicarboxylic acid 1-*tert*-butyl ester 2-methyl ester



- To a stirred solution of (2S, 4R)-4-hydroxy-pyrrolidine-1,2-dicarboxylic acid 1-tert-butyl ester 2-methyl ester (CAS Reg 74844-91-0) (6.1kg, 24.87mol), 3-chlorophenol (3.52kg, 27.39mol) & triphenylphosphine (7.18kg, 27.37mol) in tert-butyl methyl ether (30.5L) at 0°C was added diisopropylazodicarboxylate (5.53kg, 27.35mol) in tert-butyl methyl ether (15L) dropwise. The mixture was stirred overnight at 20°C. The reaction was filtered and the liquors washed with 0.5M sodium hydroxide (aq) (2 x 12.5L) & water (12.2L). The tert-butyl methyl ether solvent was replaced with n-heptane (42.7L) by atmospheric pressure distillation & cooled to crystallise crude product, which was collected by filtration (11.1kg, 125% contaminated with ca 35% reduced diisopropyl dicarboxylate & triphenylphosphine oxide - corrected yield = 86%).
- ¹H NMR (400MHz, CDCl₃): δ = 1.46, 1.49 (2 x s, 9H), 2.47 (2H, m), 3.71 (5H, m), 4.42 (1H, m), 4.42, 4.54 (1H, 2 x m), 4.87 (1H, m), 6.68 (1H, m), 6.79 (1H, s), 6.92 (1H, m), 7.18 (1H, m).
- LRMS (Electrospray): m/z 378 (MNa⁺).

Preparation 2

(2S, 4S)-4-(3-Chloro-phenoxy)-pyrrolidine-1,2-dicarboxylic acid 1-tert-butyl ester



- To the products of preparation 1 (11.1kg, 20.28mol) in THF (26.6L) was added a solution of LiOH.H₂O (4.86kg, 115.4mol) in water (55.5L). The mixture was stirred overnight at 25°C. The THF was removed by distillation & the resultant aqueous solution extracted with dichloromethane (33.3L & 16.7L). The combined dichloromethane layers were extracted with water (33L & 16.7L). The combined aqueous phases were adjusted to pH 3-3.5 with 1M hydrochloric acid(aq) & extracted with dichloromethane (2 x 22.2L). The

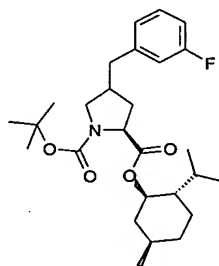
combined dichloromethane phases were replaced with toluene (33.3L), which was cooled to crystallise the product, which was collected by filtration (6.1kg, 98%).

¹H NMR (400 MHz, CDCl₃): δ = 1.42, 1.48 (2 x s, 9H), 2.30-2.70 (m, 2H), 3.60-3.80 (m, 2H), 4.40-4.60 (m, 1H), 4.86 (m, 1H), 6.71 (m, 1H), 6.82 (m, 1H), 6.94 (m, 1H), 7.16 (m, 1H).

LRMS (Electrospray): m/z [MNa⁺] 364, 340 [M-1] 340.

Preparation 3

4-(3-Fluoro-benzyl)-pyrrolidine-1,2-dicarboxylic acid 1-tert-butyl ester 2-(2-isopropyl-5-methyl-cyclohexyl) ester.



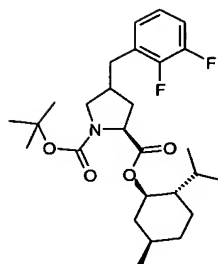
4-(3-Fluoro-benzylidene)-pyrrolidine-1,2-dicarboxylic acid 1-tert-butyl ester 2-(2-isopropyl-5-methyl-cyclohexyl) ester (1.20 g, 2.61 mmol) was dissolved in ethyl acetate:toluene (1:1, 12 ml). The solution was submitted to hydrogenation on platinum oxide (120 mg, 10 % by weight) at 25 °C and 15 psi for 1 hour. The reaction mixture was filtered through arbolcel and the filtrate reduced under pressure. The residue was purified by flashmaster chromatography eluting with heptane:ethyl acetate (15:1) to yield the title compound as a colourless oil (1.11 g, 91 %).

¹H-NMR (400MHz, CD₃OD): δ = 0.72-1.37 (m, 13 H), 1.44 (d, 9H), 1.43-1.75 (m, 4H), 1.87-2.01 (m, 2H), 2.31-2.58 (m, 2H), 2.83 (d, 2H), 3.07 (t, 1H), 3.50-3.65 (m, 1H), 4.13-4.30 (dt, 1H), 4.71 (td, 1H), 6.90 (d, 2H), 7.00 (d, 1H), 7.30 (q, 1H).

LRMS (APCI): m/z [MH-BOC]⁺ 362.

Preparation 4

4-(3-Fluoro-benzyl)-pyrrolidine-1,2-dicarboxylic acid 1-tert-butyl ester 2-(2-isopropyl-5-methyl-cyclohexyl) ester



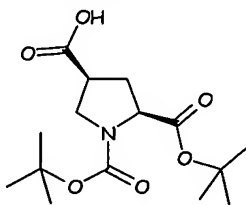
was prepared by a method analogous to that of Preparation 3 using the appropriate starting alkenic menthol ester;

[MH]480

- 5 Microanalysis (mixture of diastereoisomers *cis* (major) and *trans*): Found: C, 67.74; H, 8.30; N, 2.90%. $C_{27}H_{39}F_2NO_4$. requires C, 67.62; H, 8.20; N, 2.92%; $[\alpha]_D^{25}$ -71.92° (c = 3.26 in methanol)

Preparation 5

- 10 (2*S*,4*S*)-Pyrrolidine-1,2,4-tricarboxylic acid 1,2-di-tert-butyl ester



- To a mixture of 4-phenyl-pyrrolidine-1,2-dicarboxylic acid di-tert-butyl ester (CAS Reg. No. 344 286-69-7)⁵ (0.78g, 2.24mmol) and sodium periodate (5.77g, 27mmol) stirring at 0°C under a nitrogen atmosphere in ethyl acetate (5.5ml), acetonitrile (5.5ml) and water (8.5ml) was added ruthenium trichloride (10mg, 0.05mmol) and stirred to room temperature over 18 hours. Diethyl ether (20ml) was added and stirred for a further 1hr. 1M hydrochloric acid (5ml) was added and the mixture extracted with ethyl acetate (3 x 30ml). Organic extracts were combined, dried (MgSO₄), filtered and evaporated under reduced pressure. The residue was purified by chromatography on silica gel, eluting with 50:50:1 ethyl acetate:heptane:glacial acetic acid to give the title compound as a colourless gum (501mg, 78%)

¹H-NMR (400MHz, CDCl₃): δ = 1.40-1.49 (m, 18H); 2.26-2.40 (m, 1H); 2.42-2.56 (m, 1H); 3.02-3.12 (m, 1H); 3.65-3.80 (m, 1.4H) & 3.80-3.88 (m, 0.6H) [rotamers]; 4.09-4.20 (m, 0.7H) & 4.20-4.26 (m, 0.3H) [rotamers]

- 25 LRMS (electrospray): [M-1] 314

Biological Data

5 Example 1: Alpha-2-delta ligands delay ejaculation in anaesthetised rat model of premature ejaculation

In order to study penile erection and ejaculation the method used was based on the methodology taught in Yonezawa *et al* (2000) Life Sciences 67, 3031-3039. For ease of
10 reference, this methodology is described below:

Male Sprague Dawley rats, weighing 350-450 g, are used. Prior to the experiments the animals are housed in groups (2 rats per cage) under controlled 12 h light-dark cycle (lights on at 07:00), constant temperature ($23\pm1^{\circ}\text{C}$) and humidity ($55\pm5\%$). They have
15 free access to standard food pellets and water.

Rats are anesthetised with sodium pentobarbitone (50mg/kg, i.p.) and are placed in the supine position. The penis is extruded from its sheath and gently held by a wooden applicator positioned at the base of the penis. The test compounds are administered
20 orally and p-chloroamphetamine (PCA) (5-10mg/kg) is administered i.p. immediately before the sheath retraction and the penile responses, including penile erection, reddening and expansion of the penile body, glans erection, engorgement and slight flaring of the glans and cup, glans erection with intense flaring of the glans, are recorded in the presence of test compound or vehicle. Latencies from PCA administration to the initial
25 penile response and ejaculation is also measured in seconds in the presence of test compound or vehicle.

The effect of a test compound on p-chloroamphetamine (PCA) induced ejaculation is also assessed by weighing the ejaculates accumulated over 30mins. A suitable method using
30 conscious rats is described in Renyi (1985) Neuropharmacology, Vol. 24. No. 8, pp 697-704.

Intracavernosal pressure may also be determined in rats anesthetised with sodium pentobarbitone (50 mg/kg, i.p.). The penis is extruded from its sheath and the
35 intracavernosal pressuer (ICP) was measured by inserting a stainless steel needle (23-

gauge) into one corpus cavernosum. The needle is attached to a heparinized saline (10U/ml)-filled teflon tube and connected to a pressure transducer (NEC-San-Ei 7500).

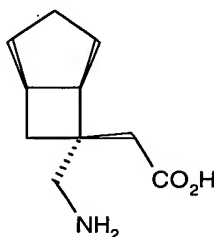
5 For all the sexual behaviour tests, the rapid ejaculating male rats were used as an animal model of premature ejaculation (classified as ejaculatory latency <300s during baseline assessment). Rapid ejaculating rats were placed in an observation arena (50-60 cm diameter), starting 5 hours into the dark cycle and observed under red illumination. Three to four minutes after placing the male in the arena, a receptive female (ovariectomised,
10 oestradiol benzoate / progesterone injection 48 hour before behavioural study) was introduced into the arena and the following parameters noted:

- i) ejaculatory latency (EJL; time taken from addition of receptive female into the arena to ejaculation);
- 15 ii) copulatory efficiency (CE; ejaculatory latency/ the number of intromissions to ejaculation, i.e. the number of seconds between intromissions);
- iii) intromission frequency (IF; the number of intromissions to ejaculation);
- iv) mount frequency (MF; the number of mounts to ejaculation);
- v) post ejaculatory interval (PEI; the time taken from ejaculation to the commencement of copulatory behaviour).

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The compound used in the following Examples was as follows:

(1R,5R,6S)-[6-(Aminomethyl)bicyclo[3.2.0]hept-6-yl]acetic acid



(XI)

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Example 1a. Delayed ejaculation in the presence of an alpha-2-delta ligand (Compound (XI))

30 An alpha-2-delta ligand, compound (XI), significantly delayed p-chloroamphetamine (PCA)-induced ejaculation in anaesthetised rats. Compound (XI) was dosed orally and

was tested at 1, 3, 10 or 30mg/kg po, 60min prior to PCA administration). Compound 1 dose-dependently increased ejaculatory latency by up to 250%. Vehicle treated animals ejaculated in circa 300s, whereas animals treated Compound 1 at doses above 3mg/kg po, displayed significantly increased ejaculatory latency to circa 1000s (See Fig1). In this study, at both 3 and 10mg/kg, 3 out of 7 animals failed to ejaculate within 30minutes, these animals were assigned ejaculatory latency of 1800s ie the end of the study in order that a mean delay could be calculated. The quality of erection was not influenced by Compound (XI) – although at 10 and 30mg/kg a small delay in the time taken to achieve erection was observed

Using a rodent model of ejaculatory, that reflects human ejaculatory physiology, we have shown that that alpha-2-delta ligands delay ejaculation. Moreover, the study shows that a alpha-2-delta ligands will be useful in the treatment of premature ejaculation by delaying ejaculation.

Example 1b: Effect of an alpha-2-delta ligand (Compound XI) on copulatory behaviour in rapid ejaculating rats

Rodent copulatory behaviour is characterised by a series of mounts, with and without vaginal insertion (50-80% of mounts result in intromission [vaginal penetration]) and ejaculation occurs after 6 to 12 intromissions. Each intromission lasts a matter of seconds - it is not possible to quantify intromission length i.e. intravaginal latency. The effect of Compound (XI) was assessed on a number of copulatory parameters (see above). We have focused ejaculatory latency as a clinical biomarker of time taken to achieve ejaculation. The study was performed in rapid ejaculating rats as a model of premature ejaculation (rats characterised by ejaculatory latency < 300s at baseline).

Compound (XI), an alpha-2-delta ligand, increased ejaculatory latency by 58% in rapidly-ejaculating conscious rats ($P < 0.01$); i.e. Compound (XI) (10mg/kg, 60min post oral dosing)-treated animals took 219s to ejaculate compared to 139s in vehicle treated animals (see Table 2 below). There were no other significant effects of on copulatory behaviour.

Table 2:

	Vehicle	Compound 1 10 mg/kg po
Ejaculatory latency (sec)	139+/-21	219+/-26 P<0.01

mean \pm sem (n=6).

Using a conscious rapid-ejaculating rodent model of premature ejaculation, that reflects human premature ejaculation pathophysiology, we have shown that an alpha-2-delta
5 ligand will be useful in the treatment of premature ejaculation by delaying ejaculation.

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